adult male examples. Some of the outlines of the orbits are drawn slightly foreshortened on account of the convexity of the dorsal surface of the carapace. The character of the stridulating-ridges will be better made out if examined with a lens.

Figs. 1, 1 *a*. *Ocypoda ceratophthalma* (Pallas).
Figs. 2, 2 *a*. *O. macrocera*, Milne-Edwards.
Fig. 2 *b*. Outer view of smaller chela of the same species, showing the somewhat dilated fingers.
Figs. 3, 3 *a*. *O. ægyptiaca*, Gerstäcker.
Figs. 4, 4 *a*. *O. rotundata*, sp. n.
Figs. 5, 5 *a*. *O. platytarsis*, Milne-Edwards.
Figs. 6, 6 *a*. *O. Gaudichaudii*, Milne-Edwards and Lucas.
Figs. 7, 7 *a*. *O. arenaria* (Catesby).
Fig. 7 *b*. Under surface of part of first ambulatory leg of the same species, showing the long marginal hairs.
Figs. 8, 8 *a*. *O. Kuhlii*, De Haan.
Fig. 8 *b*. Under surface of part of the first ambulatory leg (from a specimen from Cape St. Lucas designated by Stimpson *O. occidentalis*).
Figs. 9, 9 *a*. *O. cordimana*, Desmarest.

XLI.—*Embryogeny of the Bryozoa; an Attempt at a General Theory of their Development, founded upon the Study of their Metamorphoses*. By Dr. JULES BARROIS.

[Concluded from p. 279.]

V. CYCLOSTOMATA.

My recent researches upon the Cyclostomata, which were undertaken specially with the object of studying the phenomena of the metamorphosis, were all carried on in the Mediterranean, which is so rich in various forms of Cyclostomata, and more particularly at Villafranca. The two principal types to which I have paid attention are the Frondiporæ and the Discoporæ; the former, remarkable for the large size of the larva, which is peculiarly well adapted for observation, and with which it is easy to obtain sections, are unfortunately difficult to obtain in great abundance. The latter are common at Villafranca about the wet dock: their larvæ are small, and only moderately well fitted for the study of the fixation; but they have the advantage of belonging to a type which closely approaches the type of the Chilostomata, and may serve perfectly as a means of comparing together the larvæ of these two great groups. Those of the Frondiporæ do not differ at all from the ordinary type that I have already described.

Larva.

When we open the young ovisac of any Cyclostome, we find it filled with small morulæ, of which the size varies from the most minute dimensions up to those of a pretty large and well-formed blastula. I had thought, on studying these little morulæ, that they were formed directly by means of a series of planes of segmentation, all passing through the centre of the primitive ovum, as is the case in numerous animals in which segmentation directly gives origin to a stage with a single layer of radiating cells.

1. A thorough investigation of these youngest stages has shown me that this was not the case; the segmentation does not at all resemble the type indicated in the preceding lines. From the very first stages the vitelline spheres glide over each other, so as to form by epibolism a kind of gastrula; and we soon meet with stages of extremely minute size, and already composed of an ectodermic layer and of a free endodermic mass in its interior. The endodermic mass becomes rapidly atrophied, and we get a small blastula, which does not follow upon a stage composed of radiating cells in which a central cavity is formed, but which has, on the contrary, originated from a true gastrula produced by epibolism in the first stages of the segmentation, and in which the endodermic mass has already disappeared.

2. It is then that the great increase commences which transforms the above little blastula (*pseudo-blastula*) into a large and spacious blastula, which becomes invaginated to give origin to a stage presenting a perfectly illusive resemblance to an archigastrula. The invaginated portion which is thus produced has nothing in common with the endoderm; it represents the sac which exists in the same fashion as in the Escharina, and is likewise formed by invagination.

3. After the gastrula (*pseudo-gastrula*), the ectoderm divides into a thick and a thin part: the former, occupying the half of the embryo which surrounds the external opening of the sac, consists of long cylindrical cells ciliated at the surface, and represents the oral surface; the second, occupying the opposite half, is formed of wider, very thin, and non-ciliated cells, and represents the aboral surface.

4. To pass from this to the complete larva, we see the whole aboral surface with flat cells bury itself suddenly in the interior of the embryo, so as to form a pallial cavity entirely covered by the oral surface.

In the hatched larvæ the median portion of the aboral surface projects into the interior of the pallial cavity, so as to form the homologue of the *hood*; but this hood, which, however, is not so well indicated as in the Chilostomata, never projects out of the cavity.

Moreover the bottom of the sac rises here, as in the Cellularina, into a sort of papilla, which more or less fills the whole of the cavity.

The larvæ of the Discoporæ are remarkable in that their general aspect is the same as that of the larvæ of the Chilostomata. Their general form is more or less discoidal; and their posterior part, inflated by the sac, is much thinner than their anterior part: the latter, which is flattened, forms in the middle a very slight depression in the form of an elongated fissure, which is very visible, especially after the fixation. We have here therefore as it were a last trace, very feeble indeed, but still perceptible, of the pyriform organ of the larvæ of the Chilostomata.

On the other hand, we do not see in the larvæ of the Discoporæ (any more than in the other types of Cyclostomata) any trace of a ciliary circlet; but this difference is not fundamental. We may regard the cells of the circlet as produced by the increase of the last row of the cells of the margin of the oral surface, an increase which may or may not exist without affecting the great structural features. The segmentation shows that these cells are formed at the expense of the aboral half of the ovum; but the study of the phenomena of the metamorphosis proves that they manifestly belong to the oral surface, of which we have every right to regard the circlet as forming the boundary. If we pass from the larvæ of the Discoporæ to those of the ordinary types, such as those of the Frondiporæ, Crisiæ, and Tubuliporæ, we shall see that a change has been effected analogous to that which takes place between the Escharina and *Bugula*; that is to say, the anterior part of the oral surface has quitted the oral pole to become vertical (adapting itself to the enclosure of the anterior part of the oral surface in the circlet). In consequence of this change the larva loses its discoidal aspect to acquire that of a small cylinder, entirely constituted by the oral surface, and pierced at each extremity by an aperture; the superior aperture gives access to the sac, the inferior one to the pallial cavity. This is the type that I have figured in my first memoir.

Metamorphosis.

This greatly resembles that of the Escharina.

1. The sac becomes devaginated to give origin, at first, as

in the Cellularina, to a lamina with two mamillæ, which, however, soon becomes flattened, and then only forms a single rounded plate, by means of which fixation is effected.

2. At the same time the issue of the aboral surface from the pallial cavity occurs, a phenomenon which takes place, like the devagination of the sac, with some rapidity; we see the devaginations (devagination of the sac and devagination of the aboral surface) effected at once at the two poles of the larva, while the oral surface which unites these two poles at first remains nearly of the same length.

3. Finally, the oral surface rolls up on itself so as to give origin to a torus nearly resembling that of the Escharina. By this process the margin of the aboral surface is brought into contact with the adhesive plate, and the cell is completely closed. The calcareous incrustation of its surface is preceded, as in the Escharina, by the secretion of a cuticular envelope, the formation of which commences here very early, and immediately after the devagination of the aboral surface.

4. The torus constituted by the oral surface and the upper portion of the adhesive plate is destined, as in the Escharina, to fall subsequently into degenerescence, forming a mass of opaque globules; further, the essential part of the polypide is also formed by the invagination of the apex of the aboral surface (representing the hood).

5. The aspect of a flattened disk, which is at first assumed by the young cell of the Cyclostomata, makes its appearance very rapidly after the margin of the aboral surface has come into contact with the adhesive plate. It long retains its circular form, with the rudiment of the polypide occupying exactly its centre. Soon after the invagination of the hood (which is effected in a straight line and not obliquely, as in the Escharina) this rudiment presents its two distinct layers; but I cannot say what is the origin of the external muscular layer. A remarkable fact, and one that shows that the Cyclostomata separated earlier from the ancestral type and are of more ancient existence than the Chilostomata*, is that the complete rudiment of the polypide retains for a considerable time (during the whole of the stage of the discoidal cell) its

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* It is no doubt through this that their larvæ present a greater reduction of the internal organs than those of the Chilostomata (see the filiation of the larvæ in the conclusions); the two facts confirm one another and furnish a mutual support. Every one knows also that the Cyclostomata are much more widely distributed in geological formations than the Chilostomata, and that they especially predominate in the most ancient strata. The study of the structure of the larva and of the formation of the cell, and palæontology furnish us with perfectly concordant results, and are conclusive as to the antiquity of the Cyclostomata.

rounded structure, composed of two concentric hemispheres, suspended from the place where the hood was situated. It is only later, at the period when the cell loses its radiate symmetry and acquires a bilateral structure, that the rudiment becomes converted into a small closed sac with a double wall, as in the Chilostomata. The epoch of this change coincides with that in which the internal torus becomes emarginate on one side to acquire a horseshoe-like shape—a change which is itself connected with the appearance of the first indication of the vertical tube of the definitive cell. The formation of this tube commences by an elevation of the anterior part of the discoidal cell. In conclusion it may be mentioned that the transparent collar with which the base of the discoidal cell is furnished is produced at the expense of the adhesive plate, of which it represents the cuticular part.

VI. Lophopoda.

The facts which I have described for the preceding species lead us to give a new interpretation to the facts already acquired as to the freshwater Bryozoa (embryogeny of *Alcyonella*), facts which suffice to enable us, notwithstanding their still incomplete state, to correlate them closely with the marine forms and to assign them a well-defined position.

Larva.—The known development is very simple:—(1) a blastula is formed, in the midst of which appears (2) a fold which rises above one of the two halves, so as to envelop it completely; lastly (3) a young polypide buds forth internally upon the part thus enveloped.

There seems to me to be no doubt from what precedes (especially if we refer back to the development of the Cyclostomata) that this blastula is a *pseudoblastula*, and the annular fold the *mantle of the larva*. The covered half, together with the internal lamina of the mantle, represents the *aboral surface*; the second half, in conjunction with the external lamina of the mantle, represents the *oral surface*. Lastly, the apex of the covered half, which gives origin to the polypide by its internal budding, represents the *hood*.

Metamorphosis.—The study of the metamorphosis confirms these homologies. The larva, in fact, becomes fixed by the oral pole—that is to say, by the extremity opposite to the aperture which leads into the pallial cavity.

Afterwards the reversal of the mantle takes place, in consequence of which the whole aboral surface issues from the pallial cavity to form the integument of the cell; while the oral surface is entirely covered so as to form a thick internal mass, which soon becomes degenerescent, forming a mass of globules comparable to that with which we are acquainted in the other Ectoprocta. There is nothing in these phenomena which does not agree absolutely with what I have described in the marine species.

To sum up, the larvæ of the freshwater Bryozoa are distinguished only by three principal characters:—1, the absence of the ciliary circlet, which is replaced by a general ciliary covering; 2, the absence of the endodermic mass; 3, the absence of the internal sac. The first two characters are common to them and the larvæ of the Cyclostomata; the third is peculiar to them; nevertheless the Ctenostomata, in the group Chilostomata, present us with an analogous example of the reduction of the sac, a reduction which is very complete, if not total as in the Lophopoda. We see therefore that the freshwater Bryozoa, in their development, do not present any important phenomenon with which the investigation of the marine types has not already made us familiar.

We may remark in passing that the great resemblances of the larvæ of Lophopoda and Ctenostomata to those of the Cyclostomata and Chilostomata seem to justify a distribution of the Ectoprocta into two great divisions:—1. Cyclostomata-Lophopoda; 2. Chilostomata-Ctenostomata.

Conclusions.

Characters of the larva.—Filiation of the larvæ.—Leaving out of consideration the accessory organs, we may endeavour to give a purely diagrammatic representation of the principal larval types, by bringing together their essential parts, which the detailed study of the metamorphosis has shown us to be of the most importance. We shall then find that a Bryozoan larva consists essentially of five principal parts:—

1. The aboral surface, or the integument of the cell (A).
2. The peripheral part (O) of the oral surface, with the circlet which is formed by its margin, destined to form the mass of globules which fills the young cell, and, no doubt, originally the connective reticulum of the general cavity.
3. The incubatory pouch (1) with the central part of the oral surface destined to form the intratentacular space.
4. The intestine (2).
5. The rudiment of the polypide (3), a portion which is already preexistent in the larvæ, in which it very generally forms a special organ called the *hood*, and takes a variable part in the formation of the polypide, sometimes forming only the aperture of the cell (Entoprocta), sometimes constituting almost the whole polypide.

1. ENTOPROCTA.—Figure 1 (Pl. XIV.) represents the ar-

rangement of these parts in the larvæ of Entoprocta. It is here that they affect an arrangement nearest to that they will have in the adult. The aboral surface already forms the integument of the larva, and the oral surface is retractile and capable of closing to form a vestibule; it only needs a rotation of the organs (1) and (2), the incubatory pouch and intestine, these quitting the vestibule to place themselves in connexion with the organ (3), the *labial thickening* of the larvæ of Entoprocta, to pass from the larval to the adult form. All the five parts are well represented, and occupy an arrangement as near as possibte to that which they are to present in the adult.

2. CHILOSTOMATA.—In figure 2 it is otherwise; the circlet has grown towards the aboral pole, raising itself above the aboral surface, and thus giving origin to a new cavity, the *pallial cavity*. At the same time the oral surface has lost the power of retracting itself into the interior in the form of a vestibule. From all this we can foresee that there will be a necessity for greater changes in the metamorphosis. In the Entoprocta, in order to pass to the first stage following fixation, it suffices for the larva to rest upon the margin of the circlet; here a greater change is necessary; before arriving at the corresponding stage a preliminary phenomenon must take place; and this consists in the *reversal of the mantle*.

The three internal parts (sac, intestine, and hood) are certainly present; but the second has become degenerescent, and now only consists of a mass of globules in which one can no longer distinguish any organization.

3. CTENOSTOMATA (fig. 3).—The type represented by the larvæ of Escharina has attained its full development among the Ctenostomata. Here the pallial cavity has become enormous, and the cells of the circlet form long ribs which occupy nearly the whole integument of the larva; the latter now merely represents a sort of little cask formed entirely by the ribs of the circlet, and at each end of which appears what remains of the primitive oral and aboral surfaces. The three internal parts are as in the larvæ of Escharina; nevertheless we find that the sac is reduced to quite rudimentary dimensions, and is evidently in course of disappearance.

4. CYCLOSTOMATA.—Figure 4 is a Cyclostome larva. The circlet is deficient all through this larval type; but the oral surface, of which it is only the boundary, has continued to grow towards the aboral pole, until at last it closes altogether above the apex of the aboral surface. Here we find carried to its highest expression the process which we have seen becoming more and more strongly marked starting from the Entoprocta, and in consequence of which the oral surface, at

first enclosed in the interior of a cavity (the vestibule) and entirely concealed by the aboral surface, gradually encroaches more and more upon the outer surface, until it forms by itself the external integument, in its turn pushing back the aboral surface into the interior of a cavity, the pallial cavity. In the most differentiated types of the group of the Chilostomata and Ctenostomata we have already seen that the aboral surface was almost entirely buried in the interior (fig. 3); nevertheless in this type the apex of that surface, which constitutes the organ called the *hood*, never ceases to project externally, and is never concealed by the cells of the circlet. In the Cyclostomata it is quite otherwise; the pallial cavity attains its maximum of extension, becomes transformed into a closed cavity, and the oral surface closes completely over the invaginated aboral surface.

As internal organs we find the sac very well developed and quite comparable to what we had in the Escharina; the thickening of the hood also exists; but we find that there is a complete disappearance of the vitelline mass of the two preceding types; the intestine, which is very well developed in the larvæ of Entoprocta, and reduced to a mass of globules in the larvæ of Chilostomata and Ctenostomata, disappears completely in the larvæ of Cyclostomata.

In a general way, the larva consists of an entirely ciliated sac pierced at each pole by a single aperture, which is very dilatable, but scarcely visible when it is closed; this sac is formed entirely by the oral surface. The superior (oral) aperture leads into the internal sac (1), the inferior (aboral) aperture into the pallial cavity. We see that the phenomenon of the reversal of the mantle must produce here a transformation still more complete than in the larvæ of Escharina; the larvæ of the Cyclostomata have diverged still more than the latter from the original arrangement (Entoprocta), which was nearer that which occurs in the adult.

5. Lophopoda.—The larvæ of the Lophopoda are to the larvæ of Cyclostomata what those of the Ctenostomata are to the Chilostomata; they resemble larvæ of Cyclostomata of which the sac has completely disappeared. This disappearance is only more complete than that I have indicated in the larvæ of Ctenostomata; the sac is suppressed without leaving any traces. Thus of the three parts indicated in the interior we no longer find more than one, namely no. 3, which of itself forms the entire polypide. The rest of the structure is comparable to that of the Cyclostomata, as in the latter the oral surface forms the whole of the integument and is closed up completely over the invaginated aboral surface.

The following Table, which reduces to three great types the different forms of the larvæ of Bryozoa, will show a recapitulation of these different characters :—

Entoprocta	Predominance of the aboral surface; vestibule at the maximum. Intestine well formed.
Chilostomata and Ctenostomata (sac reduced)	Predominance of the circlet; pallial cavity. Intestine reduced to a mass of globules.
Cyclostomata and Lophopoda (without sac).	Predominance of the oral surface. Pallial cavity at the maximum. Intestine has disappeared.

If we place ourselves, in the first place, at the point of view of the larval forms alone, it would appear that we have here an essential character based upon the antagonism of the two great cavities which occupy the two poles, and, in final analysis, upon the greater or less *development of the mantle.* It is in accordance with the extension of the latter that each of the two surfaces of which the embryo consists may be by turns enclosed in the interior (the oral surface invaginated as a vestibule, or the aboral surface as a pallial cavity) or may form the totality of the integument of the larva; further, we ascertain that when the *medium extension of the mantle* (2) occurs, we also find the state of incomplete disappearance of the intestine (replaced only by a mass of globules), while the complete disappearance of the intestine corresponds to the case of maximum extension. In one word, it would seem, to a certain extent, that we have here an essential character, to which all the others appear to be subordinated, and which enables us to arrange all the larval forms in a single series, at the same time progressive from the point of view of the extension of the mantle, and decrescent as regards the development of the internal organs.

If we now place ourselves at a more general point of view, embracing at one glance the entire development, we shall see that this character of *development of the mantle*, although serving to establish the filiation of the larvæ, has nevertheless no considerable importance as regards the development taken as a whole, since all the forms of larvæ, to whatever type they may belong, are invariably brought to the same type by the first changes which follow fixation, a common type in which all trace of the mantle disappears to give place to a stage in which the oral surface is immersed as a vestibule and the aboral surface exposed as integument.

Conclusion.—In (1) the development of the mantle in the larvæ of Bryozoa, as well as in (2) the reduction of the internal organs which accompanies it, and even in (3) the very existence of this mantle, we must see only a series of *purely adaptive* characters, which, although very important in the distribution of the larvæ of Bryozoa in a natural series, do not belong at all to the normal development, and are only products of life in a free state, between the hatching of the larva and its fixation.

All this is demonstrated:—1, by the important fact that the larvæ of Entoprocta (which, as every thing indicates, must be regarded as the ancestral form) are of all the *least different* from the adult form; 2, by the fact that, starting from this first form, we can now follow step by step the modifications of the different other forms; lastly, 3, by the fact that with all these other forms the first phenomena of the metamorphosis consist in a return, not to the state of a cystide, but to an arrangement analogous to that of the larvæ of Entoprocta, and nearer to that of the adult form; for this is the signification that must be ascribed to the important phenomenon of the reversal of the mantle, with disappearance of the pallial cavity, and reconstruction of the cavity of the vestibule.

The regular course of development would consist in the direct transformation into the adult of an organism resembling a larva of Entoprocta; the rest (that is to say, all that serves to change the Entoproct larval type to give origin to the other larval types that I have described) only constitutes purely adaptive phenomena, perturbatory of the regular course of the embryogeny, and acquired during the course of life in the free state.

MECHANISM OF THE TRANSFORMATION.—CHARACTERS OF THE ADULT.

Let us now endeavour to form a general idea of the manner in which the adult state is fashioned, starting from the common stage which follows fixation; by this means alone we shall find the answer to the problem that we set before us at the commencement—namely, *to unite the two successive forms* (larva, adult) *of the embryogeny*, and especially *to appreciate the structure of the adult according to the data of embryogeny.*

It is not difficult to refer to the same type the two principal modes that we have described of the passage from the larva to the adult in the Entoprocta and Ectoprocta. The first phenomenon in either case consists in the immersion of the oral surface within the embryo, accompanied by an extension of the aboral surface, which spreads out so as to form the whole of the integument which will give origin to the definitive cell.

We then see that the oral surface, entirely invaginated into the interior of the embryo, divides into two completely different parts, one of which remains adherent to the base of the cell, while the second advances upwards to connect itself with the special invagination of the aboral surface (invagination of the hood in the Ectoprocta, labial thickening in the Entoprocta), and constitute with it the future polypide.

In the Entoprocta this second part, or superior division of the vestibule, is greatly developed, and consists of the median portion of the oral surface, which bears the incubatory pouch, and to which the intestine is suspended; it forms of itself almost the entire polypide, while the invagination of the aboral surface hardly gives origin to more than the aperture of the cell. In the Ectoprocta it is otherwise: the upper part of the wall of the vestibule only consists of a small cellular mass which comes to surround the principal portion of the polypide, of which it will form no more than the musculo-connective appendages; the essential part or epithelial lamella of the future polypide is here furnished entirely by the invagination of the aboral surface.

To sum up, we see that in both cases the polypide is formed by the union of two rudiments of very distinct origin; these rudiments encroach upon each other in such a manner that sometimes one, sometimes the other, plays the essential part in the formation of the polypide. This proves nothing against the general concordance which otherwise exists in the general phenomena. We have already noticed that in the Ascidia we see in the same way one of the most important portions, the *cloacal sac*, situated between the two primitive lamellæ, and formed sometimes by one, sometimes by the other of these lamellæ. It must further be noted that, in the Ectoprocta, the great development of the invagination of the hood, and the predominant part which it takes in the formation of the polypide, also depend certainly in great part upon the degenerescence of the intestine, which is itself the sequel of the larval state. In most types, moreover, we see the mass of globules which represents the digestive tube of the larva join itself onto the cæcal extremity of the polypide, so as likewise to take part in its formation.

The lower portion of the vestibule, including the circlet which forms part of it, enters into degenerescence in both types, so as to form the thick mass of globules which plays such an important part in the embryogeny of the Chilostomata. It would appear nevertheless, as is especially noticeable in the Entoprocta, that the primary function of this lower part is to give origin to a connective reticulum, which fills the whole cavity of the peduncle, and which, I think, we may regard as the homologue of the funiculus of other Bryozoa. It seems probable that all the oral surface must, in the ancestral type, be regarded as divided into three parts:—1, the upper part, destined to form the tentacular chamber, and into which would open in the types in question, below, the digestive tube and above, the invagination of the aboral surface destined to form the aperture of the cell; 2, the pedal gland, formed by the circlet; and 3, the intermediate portion, the margin of the vestibule, reduced to a cord uniting the gland with the polypide, entirely composed of connective cells, and representing the funiculus in the Ectoprocta, and in the Entoprocta the connective reticulum of the peduncle.

If from these data we attempt to construct a general type of adult Bryozoon, we shall see that there are grounds for distinguishing three surfaces:—1, the *foot*, corresponding to the oral pole; 2, the *frontal surface*, corresponding to the surface which answers to the mouth (figs. 6, 7, 8, *Fr*); and 3, the *tergal surface*, corresponding to the anus (figs. 6–8, *Tg*), the two latter surfaces both forming parts of the *aboral surface* which forms the entire integument.

In the Entoprocta these three distinct surfaces are easily recognized; and fig. 6, in which I have further carefully indicated the separation of the calice and peduncle, will show plainly at the first glance the distinctness of these three great divisions.

In the Ectoprocta the original arrangement seems to me to be that in which the cell comes to be developed in the direction of its height, as in the *Serialariæ*, *Bugulæ*, &c.; in these forms (fig. 8) we also very clearly distinguish the three surfaces, *pedal* (*Pd*), *frontal* (*Fr*), and *tergal* (*Tg*). Lastly, in the forms which are spread out into a plate, such as the Escharina and the majority of the Chilostomata, we can strictly establish the same distinction as I have shown in fig. 7. It is indeed to be noted that, in this last type, it is the tergal face whose growth almost always gives origin to the first bud*.

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* In a multitude of groups the terms *ventral* and *dorsal* have been the source of endless confusion and ambiguity—among the Bryozoa, to take only a single example. The authors who give the name of the ventral surface to the surface applied against the ground for reptation, will regard the fixed surface (*Pd*) as ventral and the free surface as dorsal; on the contrary, those who regard as ventral the surface upon which the mouth opens will regard the free surface as ventral and the fixed surface as dorsal. The two kinds of interpretation have already been made use of without either of them satisfying the mind; for both characters (application against the ground and the existence of a mouth) are justly

There remains, however, a fact that I cannot explain, and which is shown by the series of figs. 6, 7, 8: while in the Entoprocta the *frontal* and *tergal* surfaces correspond to the *posterior* and *anterior* surfaces (that is, in the opposite direction) of the larva, we see, on the other hand, that in the Ectoprocta the frontal and tergal surfaces correspond to the surfaces of the same name [in the larva], the *frontal* to the *anterior*, and the *tergal* to the *posterior**. Figs. 6, 7, and 8 will show this difference; it is an anomaly that I cannot explain, at least unless we assume that the pyriform organ (figs. 7, 8, *ant.*), hitherto regarded as indicating the anterior part in the morphological sense—*i. e.* corresponding to the subbuccal appendage (fig. 6, *ant.*) of the larvæ of Entoprocta—corresponds, on the contrary, to the posterior part, which certainly seems at least doubtful, although, perhaps, its impossibility is not demonstrated.

SIGNIFICATION OF THE METAMORPHOSIS.

The Table of larval forms, already given, justifies us in regarding fig. 1, the Entoproct larva, as representing the ancestral type of the entire group. To this, in fact, we have referred all the larvæ, showing by what series of modifications, from this primitive form, were produced all the other types that we know; we have seen that the Entoproct larva possessed the most complete organization of all, and that in all the other forms the primordial type has been altered.

On the other hand, the study of the metamorphosis has shown us that there exist in all two great types of the transformation of the larva into the adult, types which present the same general phenomena, but in a more explicit manner in the former. In a word, the development of the Entoprocta may be regarded as a dilated (palingenesic) and ancestral type of embryogeny, while that of various Ectoprocta, on the contrary, represents the condensed (cænogenesic) and derived form.

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employed to characterize the ventral surface. We avoid these ambiguities, and at the same time conform to all morphological and physiological requirements, by calling the fixed surface *oral*, and the free surface *aboral*, the latter being divided again into *frontal* (bearing the mouth) and *tergal* (corresponding to the anus).

* If we suppose that in fig. 6 the digestive tube is turned through a semicircle, so that its anal and buccal apertures are directed downwards, we shall see that the mouth will come to be superposed upon the subbuccal organ, *ant.* If we perform the same operation with figs. 7 and 8 we shall see that it is the anus that comes to be superposed upon the prebuccal mass, *ant.* It is in this that lies the want of concordance that I cannot explain.

Thus, if we would now inquire what signification must be ascribed to the mode of development just explained, we cannot do better than take as our exclusive basis the development of the Entoprocta, since it is this which serves as a starting-point for all the rest. An ideal type, based upon a mixture of the essential characters observed in the different types, would furnish us only with a sort of mean between the characters of the different families. The larvæ of Entoprocta, on the other hand, represent the primitive type from which all the others are derived; and this is what we want if we desire to appreciate the nature of the embryogenic phenomena and arrive at comparisons with neighbouring groups.

Without wishing to prejudge any thing with regard to the affinities which it is desirable to attribute to the Bryozoa, it may be remarked (and this no one can deny) that in the whole extent of the subkingdom *Vermes* the Bryozoa are perhaps the only forms, with the exception of the Rotifera, in which the *telostomian* arrangement is manifested in a constant manner throughout the whole group, whether during the course of development or in the adult state. It may be said, taking up a general point of view, that the Bryozoa, as also the Rotifera, are organisms *constructed upon the telostomian plan*—that is to say, in which the division of the body recalls the primitive division of the gastrula, with an oral and an aboral pole. These are, apparently, the only two groups of Vermes in which this arrangement continues so permanent.

Moreover, among the primitive Bryozoa (Entoprocta), as in the Rotifera, the aboral surface forms from the first the entire integument, while the oral surface is retracted into a vestibule, surrounded by a more or less developed circlet of cilia.

As a matter of fact (whatever may be the value of this approximation, whether it constitutes a real relationship or is only a simple analogy), an Entoproct larva, at least in the free state, represents a form constructed on the same plan as a Rotifer; it is a perfectly comparable organism as regards the great divisions of the body. This being established, we shall come to conceive of the original formation of a Bryozoan at the expense of its larva *as resulting from a simple change of life* in an organism resembling a Rotifer. We know that frequently the larvæ of Entoprocta, instead of swimming through the liquid in the manner of a Rotifer, reverse their position and proceed to creep upon their oral surface, as shown in fig. 9. Now if this habit becomes more frequent, the larva gradually abandoning its first mode of life to adopt the second, this change of manners might be the source of the metamorphosis that we have observed. The larva, in creeping, must, by means of its cilia, give rise to a current destined to carry towards its mouth the alimentary particles upon which the animal feeds; now we may suppose that this current, passing beyond the mouth, comes to strike against the anal extremity of the vestibule, pushing back the latter gradually towards the superior extremity of the larva, and finally producing the movement of rotation of all this part of the oral surface, carrying with it the digestive tube. We thus obtain a mechanical explanation of the fundamental phenomenon of the metamorphosis.

To conclude, we may put forward the hypothesis of the very ancient existence of a group of *Probryozoa*, composed of swimming organisms, free, and possibly analogous to the Rotifera (at least as regards the aspect and general arrangement of the body), and of which the few larvæ of Entoprocta that we know now-a-days represent the sole survivors; from this group the existing Bryozoa are derived by adaptation to a new mode of life: certain larvæ have accustomed themselves to creep, as indicated by fig. 9, upon their oral surface, instead of swimming freely through the water; and hence the changes already described, which produce the Bryozoan form, and the efficient cause of which may be ascribed to the current which flows into the mouth of the animal.

EXPLANATION OF PLATE XIV.

Explanation of the letters.

1. Rudiment of the polypide (*hood*).
2. Intestine or vitelline mass.
3. Internal sac or cloaca.

Fr. Frontal surface of adult.
Tg. Tergal surface.
Pd. Inferior surface or foot.
ant. Subbuccal (Entoproct) or prebuccal (Ectoproct) organ indicating the anterior part of the larva.
o. Vestibule.
a. Pallial cavity.
fun. Attenuated portion of the oral surface, uniting the half which forms part of the polypide to that which forms the rest of the invaginated vestibule.

Explanation of the figures.

The parts in black represent the oral surface, the parts in grey the aboral surface; the internal organs are left white.

Figs. 1–5 represent the five principal larval types, showing the variable extent of the oral (black) and aboral (grey) surfaces in each of them, as well as the extent attained by the three principal internal organs (1, 2, 3).

Fig. 1. Larva of an Entoproct. The aboral surface is very large and forms the whole integument. The oral surface is small and sunk into a vestibule. The three internal organs are well developed.

Fig. 2. Larva of a Chilostome. The two surfaces are of nearly equal importance; the chief part of the integument is formed by the circlet which represents the margin of the oral surface. The latter has lost the faculty of becoming retracted into a vestibule; and the aboral surface is invaginated into a *pallial cavity.* In the internal organs we observe the reduction of a first internal organ (no. 2), which, instead of forming a complete intestine, has become reduced to a mass of vitelline globules.

Fig. 3. Larva of a Ctenostome. Characters as in the preceding, but further presenting the reduction of a second internal organ, the sac (no. 3), which has become reduced to a little mass with no cavity.

Fig. 4. Larva of a Cyclostome. The oral surface forms the whole of the integument of the larva, and is completely closed over the aboral surface. The pallial cavity is thus transformed into a closed cavity. Of the internal organs the vitelline mass (2) has completely disappeared.

Fig. 5. Larva of a Lophopode. Characters as in the preceding, except that here the disappearance of the vitelline mass is associated with the complete disappearance of the sac.

Fig. 6. Young cell of a Chilostome immediately after the metamorphosis. We see the construction of the polypide at the expense of the three parts 1, 2, 3.

Fig. 7. Young cell of an Entoproct, showing the agreement with the preceding figure. In the polypide the white part represents what is derived from the organ no. 1 (*hood*), the grey part what is derived from the oral surface; the dotted part recalls the part taken sometimes by the residue of the opaque globules in the formation of the cæcum of the stomach: the polypide thus shows that it is composed of three parts (1, 2, 3), which may be regarded as corresponding to the three internal organs (1, 2, 3) of the larvæ.

Fig. 8. Young cell of a Ctenostome (*Serialaria*) represented in the same way.

These two figures, which alone may give a complete idea of the adult organism in the Ectoprocta, do not exist in nature, the invaginated vestibule always disappearing before the complete formation of the polypide; but it is necessary to represent the two things simultaneously, in order to form a general idea of the animal. These two figures show us the position of the polypide with relation to the invaginated vestibule.

Figs. 6, 7, 8 show, further, the homologies of the different surfaces in the pedunculate Bryozoa (fig. 6), the Bryozoa with flat cells (fig. 7, Escharina), and the Bryozoa with tubular cells (fig. 8, Cellularina, Ctenostomata, &c.). The correspondence is complete in all respects except the orientation of the polypide.

Fig. 9. Entoproct larva in the creeping state, to show the commencement of the immersion of the vestibule in the interior.